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Water Quality Water Supply Study Arkansas River Basin John Martin Dam Colorado to Great Bend Kansas Draft

Environmental Protection Agency, Dallas, Tex Region VI

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Reservoir storage for water quality control releases is not justified. There are several municipalities in the study area that would benefit from developing a new source of water supply of a better quality. Groundwater which presently supplies all municipal systems in the area is variable in quality and some cases not suitable for municipal and industrial uses. Heavy pumpage of groundwater for irrigation has lowered groundwater table in local areas and mining is occuring. If this continues at present rate and is not regulated the mining will become widespread and result in depletion of groundwater resources. The "Horse Thief Canyon Reservoir Project" could satisfy a protion of water supply demands for communities benefiting from developing new water supplies of better quality. Limited groundwater data presently available and uncertainty regarding the future mining of groundwater resources, make it impossible to determine the most economical source of future municipal and industrial water supply need.

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WATER QUALITY - WATER SUPPLY STUDY
ARKANSAS RIVER BASIN
JOHN MARTIN DAM, COLORADO
TO
GREAT BEND, KANSAS

PREPARED FOR

DEPARTMENT OF THE ARMY

U. S. ARMY ENGINEER DISTRICT

ALBUQUERQUE, NEW MEXICO

ENVIRONMENTAL PROTECTION AGENCY

REGION VI

DALLAS, TEXAS

JANUARY 1972

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SUMMARY OF FINDINGS AND CONCLUSIONS

Reservoir storage for water quality control releases is not justified. There are several municipalities in the study area that would benefit from developing a new source of water supply of a better quality. Groundwater, which presently supplies all municipal systems in the study area is variable in quality and in some areas is not suitable for municipal and industrial uses. Heavy pumpage of groundwater for irrigation has lowered the groundwater table in local areas and mining is occuring. If groundwater pumpage for irrigation continues to increase at present rates and is not controlled or regulated, the mining will become widespread and result in a depletion of groundwater resources. With proper control and regulation of groundwater production for irrigation uses, the present groundwater resources appear adequate to satisfy the projected municipal and industrial water supply demands. The "Horse Thief Canyon Reservoir Project" could satisfy a portion of the water supply demands for those communities that would benefit by developing new water supplies of better quality. However, the limited groundwater data presently available and uncertainty regarding the future mining of ground water resources, make it impossible to determine the most economical source of supplying future municipal and industrial water supply need. Accordingly, it is suggested that the appropriate Federal and State agencies make a detailed study to determine the "safe yield" of the groundwater reservoir and to define specific areas suitable for development of groundwater for municipal and industrial uses. Until a study of this scope has been completed and the States establish

a program for the managment of groundwater resources, the benefit attributable to development of surface water for municipal and industrial uses cannot be evaluated.

WATER QUALITY-WATER SUPPLY STUDY
ARKANSAS RIVER BASIN
JOHN MARTIN DAM, COLORADO
TO
GREAT BEND, KANSAS

I. Purpose of Study

The purpose of the study is to determine the need for and value of reservoir storage to the year 2070, for water quality control purposes and municipal and industrial water supply for a portion of the Arkansas River Basin drainage area between John Martin Dam, Colorado and Great Bend, Kansas. The drainage area includes all or portions of 11 counties in Colorado and 18 in Kansas. The twenty one counties included in the study area are as follows:

Colorado	Kansas		
Cheyenne	Barton	Haskell	Pawnee
Elbert	Edwards	Hamilton	Rush
Kiowa	Finney	Hodgeman	Scott
Lincoln	Ford	Kearny	Wichita
Prowers	Gray	Lane	
	Greeley	Ness	

The remaining 8 counties in the drainage area were excluded from the study area because only a small portion of each lies within the subbasin.

II. Projects Being Considered

The Albuguerque District Corps of Engineers is presently investigating the feasibility of two reservoir sites. The first of these is the "Kendall Lake Project" on the mainstream of the Arkansas River. The damsite for this project is located at about River mile 1,070 of the Arkansas River. The reservoir would contain the following amounts of storage:

Purpose	Storage, Acre-Feet
flood control	230,000
irrigation	50,000
sediment reserve	152,000
recreation	18,000
TOTAL	450,000

The second project being investigated is the "Horse Thief Canyon Reservoir Project." The damsite of this project is located on Buckner Creek above Jetmore, Kansas. Curves furnished by the Corps of Engineers show that this project could supply the following annual yields:

2% net yield	2,000 acre feet
10% net yield	5,000 acre feet

The primary project purposes being considered at this site are water supply and recreation.

III. Water Quality

A. Inorganic Quality

(1) Arkansas River

That portion of the Arkansas River between John Martin Dam, Colorado and Great Bend, Kansas is very poor in chemical quality. This is attributable to the use and re-use of the water for irrigation as it passes through Colorado and Kansas. Chemical analyses for three stations on the Arkansas River for the water year of 1969 are shown in Table 1.

Because of the high sulfate concentrations and total dissolved solids the proposed Kendall Lake Reservoir project would not provide water that would be of suitable quality for municipal and industrial uses. The limited present and anticipated water resources in the basin make it impractical to provide supplemental flows for reducing the concentration of inorganic constituents.

TABLE 1

QUALITY ANALYSIS ARKANSAS RIVER - FLOW WEIGHTED MEAN ANNUAL CONCENTRATION, WATER YEAR 1969

STATION	CHEMICAL CONSTITUENT - PPM														
Arkansas River	FE	MN	CA	MG	NA	K	HCO_3	CO_3	SO_4	Cl	F	NO_3	PO_4	B	TDS
1. Near Great Bend	0.13	0	148	51	163	11	232	0	638	66	0.9	7.7	1.1	0.26	1,223
2. Near Dodge City	0.01	0	211	78	250	13	235	-	1,054	84	1.0	9.0	0.7	0.34	1,837
3. Below John Martin Reservoir	-	-	283	144	356	-	257	-	1,670	104	-	4.2	-	-	2,920

TABLE 2

QUALITY ANALYSIS - BUCKNER CREEK NEAR JETMORE, KANSAS

DATE OF SAMPLE	CHEMICAL CONSTITUENT - PPM												
	CA	MG	NA	K	HCO_3	CO_3	SO_4	Cl	F	NO_3	PO_4	TDS	Total Hardness
6/23/69	62	19	22	9.7	215	19	48	22	1.1	2.4	2.3	338	258
3/11/68	64	21	23	5.8	264	0	44	23	1.1	0.4	0.20	342	276
10/24/66	78	14	29	13	295	0	58	22	0.9	0.9	-	390	262
3/23/70	66	17	23	6.8	264	0	42	22	1.1	0.9	0.19	350	234

SOURCE: United States Geological Survey

(2) Buckner Creek

Chemical analyses of a limited number of samples taken from Buckner Creek indicate that the water quality of this stream would most likely be of acceptable quality for municipal uses. Four samples taken on Buckner Creek near Jetmore, Kansas and their chemical analysis are shown in Table 2.

While the existing analysis show that the water of Buckner Creek is good in quality, it is possible that the limited number of samples do not accurately reflect the true quality conditions. Prior to recommending development of this stream for municipal and industrial water supply uses additional stream analysis would be necessary. In addition to stream samples, the drainage area above the Horse Thief Canyon Dam site should be investigated to insure that rainfall and percolation through the soil would not cause high concentrations of dissolved minerals in the impounded waters.

B. Organic Quality

In evaluating the need for reservoir storage to provide supplemental stream flow for the dilution of municipal and industrial wastewater only those discharge points below the proposed reservoir sites were considered. It was assumed that all of these waste discharges were receiving adequate treatment prior to discharge into the stream system. In view of the Environmental Protection Agency's proposed policy concerning the assessment of reservoir storage for water quality control and pending legislation, the following levels of wastewater treatment were used in evaluating water quality control storage needs:

(1) 1970 - 90% BOD removal
(2) 1985 - 95% BOD removal
(3) 2000 and thereafter- complete recycling and re-use of waste water

It was also assumed that the minimum dissolved oxygen concentration allowed in the streams would be 4.0 milligrams per liter.

(1) Arkansas River

There are presently 14 municipalities and five industries located on the Arkansas River downstream from the Kendall Lake Reservoir Dam site that discharges or have the potential to discharge wastewater into the Arkansas River. The five industries that have private treatment facilities are shown in Table 3.

The 14 municipalities located on the Arkansas River below the Kendall Lake site are shown in Table 4. While some of the communities discharge to dry tributaries of the Arkansas River, for this evaluation it was assumed that the communities discharge their treated wastewater into the Arkansas River. The monthly streamflows required to maintain a dissolved oxygen concentration of 4.0 milligrams per liter were developed using present and projected wastewater discharges and the treatment levels previously described. These flows shown in Table 5 are the gross streamflow requirements. The critical point in the stream is below the discharge points of Garden City and Dodge City. In evaluating the streamflow requirements it was assumed that the required flow would be released from the proposed Kendall Lake Reservoir and would be available for the assimilation

TABLE 3

INDUSTRIAL WASTE DISPOSAL-ARKANSAS RIVER

COMPANY NAME	LOCATION	TREATMENT METHOD	DISCHARGE TO
Heizer By-Products	Great Bend	Lagoons	Irrigation
Theiss Packing Company	Great Bend	Lagoons	No discharge
Cargill Incorporated	Pawnee Rock	Ponds	1/
Century Refining	Garden City	Disposal Wells	No discharge
Farmland Industries	Dodge City	Disposal Wells	No discharge

1/ Plans and specifications being prepared for deep disposal wells.

TABLE 4
MUNICIPAL WASTE DISPOSAL-ARKANSAS RIVER

COMMUNITY	APPROXIMATE RIVER MILE of DISCHARGE POINT	1970 VOLUME OF DISCHARGE cfs
Lakin	1,048	0.25
Deerfield	1,040	0.08
Holcomb	1,032	0.05
Garden City	1,025	2.27
Ingalls	998	0.04
Cimmaron	992	0.21
Dodge City	973	2.19
Ford	956	0.04
Kinsley	924	0.34
Garfield	912	0.05
Larned	902	0.91
Pawnee Rock	891	0.07
Great Bend	878	2.49
Ellinwood	866	0.38

TABLE 5

GROSS STREAMFLOW REQUIREMENTS (cfs)

ARKANSAS RIVER BELOW KENDALL LAKE RESERVOIR

MONTH	1970	1985	2000
January	0.0	0.0	0.0
February	0.0	0.0	0.0
March	0.40	0.0	0.0
April	2.12	0.0	0.0
May	4.23	0.52	0.0
June	7.74	2.51	0.0
July	9.93	3.87	0.0
August	9.30	3.52	0.0
September	6.37	1.62	0.0
October	2.89	0.17	0.0
November	0.38	0.0	0.0
December	0.0	0.0	0.0

of waste discharges throughout the dow..stream reach. A comparison of the gross streamflow requirements with existing base flows is shown in Table 6.

The base low flows were computed using streamflow records of the United States Geological Survey at Garden City for the period 1945 through 1968. The base flow was considered to be the runoff that would be coincident with a drouth having a recurrence interval of once in 20 years or the annual runoff that would be expected to be exceeded 95 percent of the time.

Monthly base flows were determined from a distribution of median monthly flows expressed in terms of the once in 20 year annual low flow. Since the primary use of Arkansas River water in the reach being considered is for irrigation it was not considered practical to use a more critical base flow in determining water quality control needs.

As can be seen in Table 6, the calculated base flows are adequate to maintain a dissolved oxygen concentration of 4.0 mg/l except during the month of September for a short period of time between 1970 and 1985. Improved levels of waste treatment will correct this deficiency and there will be no need to provide supplemental streamflow for water quality control.

TABLE 6

STREAMFLOW ANANLYSIS-ARKANSAS RIVER AT GARDEN CITY, KANSAS

STREAM FLOW (cfs)	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
1970												
Required flow	0.0	0.0	0.40	2.12	4.23	7.74	9.93	9.30	6.37	2.89	0.38	0.0
Low flow	42.8	54.4	25.1	12.7	9.1	35.6	11.0	12.4	3.6	5.5	22.9	40.8
Supplemental flow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.77	0.0	0.0	0.0
1985												
Required flow	0.0	0.0	0.0	0.0	0.52	2.51	3.87	3.52	1.62	0.17	0.0	0.0
Low flow	42.8	54.4	25.1	12.7	9.1	35.6	11.0	12.4	3.6	5.5	22.9	40.8
Supplemental flow	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

(2) Buckner Creek

There are 5 waste discharge points in the stream system below the Horse Thief Canyon Reservoir site that is being considered on Buckner Creek. Two of the waste points discharge into Buckner Creek while the remaining three discharges are located on Pawnee River downstrean from the confluence of Buckner Creek and Pawnee River. Table 7 provides information on these discharges.

In accordance with the treatment levels and criteria previously discussed, the gross streamflows required to maintain desirable dissolved oxygen concentrations in Buckner Creek and Pawnee River are shown in Table 8. It was assumed that by the year 2000 waste water would be treated to a level that would permit recycling and re-use; therefore, there would be no need for supplemental streamflow for water quality control after this time.

The critical area of depressed dissolved oxygen levels in Buckner Creek is below the discharge of Jetmore's effluent while the critical reach in the Pawnee River is below Larned State Hospital. No streamflow records are available on Buckner Creek to determine the base low flow of the stream. However, since the drainage area above Jetmore is small, and there is little contributing drainage area, frequent periods of no streamflow are expected.

TABLE 7
MUNICIPAL WASTE DISPOSAL-BUCKNER CREEK-PAWNEE RIVER

COMMUNITY	RECEIVING STREAM	1970 VOLUME OF WASTEWATER EFFLUENT (
Jetmore	Buckner Creek	0.14
Hanston	Buckner Creek	0.04
Burdett	Pawnee River	0.04
Rozel	Pawnee River	0.04
Larned State Hospital	Pawnee River	0.46

TABLE 8

GROSS STREAM FLOW REQUIREMENTS (cfs) BUCKNER CREEK-PAWNEE RIVER

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEPT	OCT	NOV	DEC
1970												
Buckner Creek	0.0	0.0	0.02	0.08	0.17	0.32	0.44	0.41	0.25	0.11	0.01	0.0
Pawnee River	0.0	0.0	0.07	0.32	0.62	1.11	1.48	1.37	0.91	0.44	0.06	0.0
1985												
Buckner Creek	0.0	0.0	0.0	0.0	0.02	0.07	0.12	0.10	0.05	0.0	0.0	0.0
Pawnee River	0.0	0.0	0.0	0.0	0.08	0.36	0.56	0.51	0.24	0.01	0.0	0.0

Streamflow records of Pawnee River indicate that low flows during the summer months would be less than that necessary to maintain desirable dissolved oxygen concentrations. However, due to the small volume of waste being received by the Buckner Creek-Pawnee River stream system, it is more practical to increase treatment levels or provide for short term storage of wastewater during low flow periods in lieu of streamflow regulation.

C. Other Pollution Problems

Other potential water pollution problems in the basin are those resulting from oil production and cattle feedlots. The state water pollution control agencies have adequate authority to control and regulate the waste disposal practices at these developments so that they will not be detrimental to water quality. Programs administered by the states have been effective in abating these potential pollution problems at the source and it is expected that they will continue to be so in the future.

IV. Municipal and Industrial Water Supply

A. Municipal Water Use

(1) Present Use

All municipal and industrial water use in the basin is presently supplied by groundwater.

Surface water of the Arkansas River is poor in quality and is not suitable for municipal and many industrial uses. The streamflow of the tributaries in the study area is erratic and periods of no flow make them unreliable as a source of municipal and industrial water supply. Tables 9 and 10 show pertinent information on municipal water systems located in the study area.

(2) Projected Municipal Water Demands

In determining the future municipal water supply needs of the study area, it was assumed that all incorporated areas would develop community water systems. Based on the data presented in Tables 9 and 10, the municipal water use in the study area in Colorado for the year 1960 was 144 gallons per capita per day, while municipal water use in the Kansas study area for 1968 was 170 gallons per capita per day. The average use for the total study area was 166 gallons per capita per day. For purposes of projecting future requirements, it is estimated that the 1970 municipal water use was at least 170 gallons per capita per day. Where existing water use records showed a consumption greater than 170

TABLE 9

MUNICIPAL WATER USE IN COLORADO 1960 1/

COMMUNITY	SOURCE	MGD	TOTAL HARDNESS	F	Cl	SO_4	TDS
Arriba	2 wells	0.04	222	0.5	16	52	341
Cheyenne Wells	4 wells	0.12	132	0.6	3	13	194
Eads	3 wells	0.12	356	1.5	47	553	1,150
Elizabeth	2 wells	0.04	114	0.4	12	34	207
Granada	2 wells	0.08	154	1.3	13	122	391
Genoa	6 wells	0.01	164		6	28	225
Hartman	1 well	0.03					
Haswell	1 well	0.02					
Holly	4 wells	0.27	250	0.9	13	172	450
Hugo	6 wells	0.20	198	1.0	17	230	667
Kiowa	2 wella	0.02	81	0.3	4	18	184
Kit Carson	2 wells	0.05	420	1.0	46	605	1,220
Lamar	20 wells	0.94	276	0.6	9	193	452
Limon	7 wells	0.18	481	0.6	13	556	1,090
Simila	3 wells	0.18	281	0.6	16	198	604
Wiley	2 wella	0.05	229	2.2	19	1060	2,090

1/ Source: Public Water Supplies of Colorado 1959-1960, Prepared by U.S.G.S. in cooperation with Colorado State University Agricultural Exp. Station

TABLE 10

MUNICIPAL WATER USE IN KANSAS

COMMUNITY	COUNTY	SOURCE	POPULATION SERVED (1968)	1968 USE MGD	1968 USE ACRE-FEET	TDS	CHEMICAL QUALITY (PPM) FE	MN	SO_4	Cl	F	TOTAL HARDNESS
Albert	Barton	NPS[1]	-	-	-	-	-	-	-	-	-	-
Alexander	Rush	1 SW[2]	150	0.02	21	556	0.06	0.0	92	22	0.2	444
Bazine	Ness	2 SW	470	0.11	125	849	0.01	0.0	252	67	0.3	554
Belpre	Edwards	1 SW	200	0.03	39	281	0.0	0.0	20	13	0.5	190
Bison	Rush	2 SW	300	0.04	42	556	0.11	0.0	36	75	0.1	412
Brownell	Ness	1 SW	130	0.02	18	361	0.0	0.0	24	32	0.2	264
Bucklin	Ford	3 DW[3]	825	0.29	321	322	0.0	0.0	17	23	0.2	254
Burdett	Pawnee	1 DW	360	0.06	70	477	0.59	0.08	77	81	2.0	96
Cimarron	Gray	4 DW	1,100	0.29	330	248	0.06	0.0	42	9	0.4	170
Claflin	Barton	3 DW	900	0.08	95	459	0.01	0.0	16	90	0.4	240
Coolidge	Hamilton	2 SW	120	0.03	30	418	0.07	0.05	144	14	1.1	204
Copeland	Gray	2 DW	275	0.06	70	220	0.07	0.05	14	8	0.3	160
Deerfield	Kearny	2 DW	425	0.07	75	385	0.07	0.0	109	20	1.0	232
Dighton	Lane	2 DW, 5 SW	1,700	0.34	380	364	0.06	0.0	57	15	3.2	233
Dodge City	Ford	11 DW	14,700	2.75	3,080	323	0.08	0.0	51	17	1.2	234
Elinwood	Barton	54 DW, 1 SW	2,850	0.43	479	920	0.01	0.0	400	80	0.8	454
Ensign	Gray	2 DW	250	0.04	49	274	0.0	0.0	26	16	0.4	180

TABLE 10 (Cont'd)

MUNICIPAL WATER USE IN KANSAS

COMMUNITY	COUNTY	SOURCE	POPULATION SERVED (1968)	1968 USE MGD	1968 USE ACRE-FEET	CHEMICAL QUALITY (PPM) TDS	FE	MN	SO_4	Cl	F	TOTAL HARDNESS
Ford	Ford	NPS	-	-	-	-	-	-	-	-	-	-
Galatia	Barton	NPS	-	-	-	-	-	-	-	-	-	-
Garden City	Finney	13 DW	15.210	2.65	2,972	464	0.10	0.0	181	22	0.7	309
Garfield	Pawnee	NPS	-	-	-	-	-	-	-	-	-	-
Great Bend	Barton	7 SW	17,800	2.18	2.439	729	0.01	0.0	125	197	0.7	282
Houston	Hodgeman	1 DW	302	0.05	55	-	-	-	-	-	-	-
Hoisington	Barton	3 DW	4,250	0.46	520	318	0.0	0.0	74	64	0.5	98
Holcomb	Finney	1 DW	280	0.02	19	306	0.0	0.0	61	12	0.9	192
Horace	Greeley	3 SW	220	0.03	31	248	0.0	0.0	14	13	0.6	190
Ingalls	Gray	NPS	-	-	-	-	-	-	-	-	-	-
Jetmore	Hodgeman	2 DW, 3 SW	1,075	0.22	248	600	0.09	0.12	101	38	0.4	458
Kinsley	Edwards	3 SW	2,400	0.39	438	195	0.0	0.0	18	8	0.4	144
LaCrosse	Rush	3 DW, 2 SW	1,900	0.20	219	317	0.0	0.0	110	46	0.2	160
Lakin	Kearny	2 DW	1,500	0.35	393	238	0.0	0.0	28	7	1.2	165
Larned	Pawnee	4 SW	5,200	0.95	1,065	1,129	0.0	0.0	565	65	0.8	550
Leoti	Wichita	4 DW	1,675	0.45	507	269	0.0	0.0	30	13	1.4	172
Lewis	Edwards	3 SW	550	0.15	163	282	0.0	0.0	18	18	0.5	194
Liebenthal	Rush	1 DW	175	0.02	24	1,741	0.12	0.11	237	670	4.4	56

TABLE 10 (Cont'd)

MUNICIPAL WATER USE IN KANSAS

COMMUNITY	COUNTY	SOURCE	POPULATION SERVED (1968)	1968 USE		CHEMICAL QUALITY (PPM)					
				MGD	ACRE-FEET	TDS	FE	MN	SO_4	Cl	F	TOTAL HARDNESS
McCracken	Rush	6 SW	480	0.04	41	534	0.03	0.0	137	53	0.6	336
Montezuma	Gray	3 DW	675	0.06	70	260	0.0	0.0	26	12	0.4	168
Ness City	Ness	12 SW	2,050	0.30	337	614	0.10	0.24	145	40	0.7	406
Offerle	Edwards	2 DW	200	0.03	39	338	0.02	0.0	24	25	1.0	190
Olmitz	Barton	2 DW	160	0.03	31	1,246	0.88	0.06	91	471	2.0	90
Otis	Rush	1 SW	380	0.02	26	473	0.0	0.0	58	47	0.2	340
Pawnee Rock	Barton	NPS	-	-	-	-	-	-	-	-	-	-
Ransom	Ness	2 SW	460	0.08	94	315	0.0	0.0	20	17	0.2	244
Rozel	Pawnee	1 DW	275	0.05	55	-	-	-	-	-	-	-
Rush Center	Rush	1 SW	250	0.03	32	462	0.59	0.15	68	30	0.5	350
Satanta	Haskell	3 DW	1,135	0.23	258	483	0.0	0.0	169	19	1.1	278
Scott City	Scott	5 DW	4,150	0.94	1,055	375	0.0	0.0	51	27	2.0	210
Spearville	Ford	4 SW, 1 DW	625	0.14	155	423	0.0	0.0	30	57	1.0	304
Sublehe	Haskell	4 DW	1,300	0.33	368	253	0.09	0.0	43	9	0.7	160
Susank	Barton	1 DW	70	0.01	10	2,187	0.67	0.0	156	945	2.8	102
Syracuse	Hamilton	2 SW	2,000	0.46	512	315	0.02	0.0	85	7	0.4	188
Timken	Rush	1 SW	145	0.02	20	389	0.01	0.0	49	15	0.1	309

TABLE 10

MUNICIPAL WATER USE IN KANSAS

COMMUNITY	COUNTY	SOURCE	POPULATION SERVED (1968)	1968 USE		TDS	CHEMICAL QUALITY (PPM)					TOTAL HARDNESS
				MGD	ACRE-FEET		FE	MN	SO_4	Cl	F	
Tribune	Greeley	3 DW	1,200	0.25	283	209	0.01	0.0	14	9	0.8	156
Utica	Ness	4 W	330	0.06	69	302	0.0	0.0	13	14	0.5	228

1/ NPS - No Public Supply

2/ SW - Shallow well less than 100 feet

3/ DW - Deep well greater than 100 feet

SOURCE: Bulletin Number 15, Kansas Water Resources Board, 1971, Inventory of Public Water and Waste Treatment Facilities

Chemical Quality of Public Water Supplies in Kansas, November 1968, Kansas State Dept. of Health

gallons per capita, the larger figure was used. It is estimated that the daily per capita water consumption will increase at the rate of one gallon per year until it reached 220 gallon per capita per day and will remain at this level for the remainder of the study period. These usage rates and population projections furnished by the Corps of Engineers were used to determine the projected municipal water demands shown in Table 11. If treatment levels of municipal wastewater improve as anticipated, it is estimated that from 40 to as much as 70 percent of the projected water supply needs beyond the year 2000 could be satisfied by re-using the wastewater for water supply.

B. Industrial Water Use

The Kansas Water Resources Board conducted an inventory of industrial water users in the Kansas portion of the study area. To accomplish this inventory, the KWRB sent questionnaires to most

TABLE 11

PROJECTED MUNICIPAL WATER USE (INDUSTRIAL USE EXCLUDED)

COUNTY	1970		1980		2000		2020		2070	
	MGD	ACRE-FEET	MGD	ACRE-FEET	MGD	ACRE-FEET	MGD	ACRE-FEET	MGD	ACRE-F
COLORADO										
Cheyenne	0.20	224	0.20	224	0.21	235	0.20	224	0.15	168
Elbert	0.29	325	0.32	358	0.42	470	0.52	583	0.75	840
Kiowa	0.23	258	0.21	235	0.18	202	0.18	202	0.14	157
Lincoln	0.39	437	0.31	347	0.21	235	0.16	179	0.09	101
Prowers	1.67	1,871	1.67	1,871	1.79	2,005	1.97	2.207	1.87	2,095
KANSAS										
Barton	4.10	4,593	4.68	5,243	6.60	7,393	8.03	8,995	8.76	9,813
Edwards	0.59	661	0.76	851	0.90	1.008	1.01	1,131	1.17	1,311
Finney	2.54	2,845	3.24	3,629	4.84	5,422	7.17	8,032	11.48	12,860
Ford	3.18	3,562	3.78	4,234	5.76	6,452	7.55	8,458	12.65	14,171
Gray	0.54	605	0.84	941	1.87	2,095	2.86	3,204	6.38	7,147
Greeley	0.23	258	0.34	381	0.41	459	0.51	571	0.70	784
Hamilton	0.41	459	0.33	370	0.29	325	0.27	302	0.27	302
Haskell	0.48	538	0.62	695	0.75	840	0.92	1,031	1.23	1,378
Hodgeman	0.24	269	0.29	325	0.32	358	0.33	370	0.36	403
Kearny	0.45	504	0.51	571	0.56	627	0.66	739	0.85	952

TABLE II (Cont'd)

PROJECTED MUNICIPAL WATER USE (INDUSTRIAL USE EXCLUDED)

COUNTY	1970 MGD	1970 ACRE-FEET	1980 MGD	1980 ACRE-FEET	2000 MGD	2000 ACRE-FEET	2020 MGD	2020 ACRE-FEET	2070 MGD	2070 ACRE-FE
KANSAS (Cont'd)										
Lane	0.31	347	0.44	493	0.57	639	0.79	885	1.54	1,725
Ness	0.50	560	0.59	661	0.69	773	0.81	907	0.95	1,064
Pawnee	0.96	1,075	1.26	1,411	1.83	2,050	2.08	2,330	2.38	2,666
Rush	0.55	616	0.76	851	1.02	1,143	1.14	1,277	1.76	1,972
Scott	0.88	986	1.08	1,210	1.54	1,725	2.13	2,386	3.28	3,674
Wichita	0.42	470	0.59	661	0.92	1,031	1.17	1,311	2.05	2,296

of the companies listed in the 1966-67 Directory of Kansas Manufacturers and Products published by the Kansas Department of Economic Developement. Utilizing the information obtained from these questionnaires, the KWRB developed coefficients relating industrial water use to dollar output value for seven industrial categories. Projections of population, employment, and dollar output by industrial category for each of the 16 counties in the Kansas study area were furnished by the Oklahoma City Development Office of the Bureau of Reclamation. This data was developed by Dr. M. Jarvin Emerson, Chief Economist for the State of Kansas, under a contract with the Bureau of Reclamation. This data is preliminary and the final report has not yet been released. Population projections furnished by the Bureau of Reclamation for the period 1980 to 2020 were slightly higher than those developed by the Corps of Engineers. Accordingly projected employment and dollar output values were adjusted downward based on the Corps of Engineers projected population. Projected industrial water use in Colorado was determined by using the water use coefficients computed by the KWRB. Employment in Colorado was obtained from the Directory of Colorado

Manufacturers, 1966, published by the University of Colorado. Output value of industrial production was estimated by using a dollar output per employee.

The projected industrial water use by counties for the study area is shown in Table 12. The projected industrial demands in Table 12 are considered to be conservative estimates since technology advances in the future will probably result in more efficient manufacturing processes which require less water. Also, as the cost and the competitive demand for water increases the conservation of water will probably be emphasized.

C. Water Supply Problems

Estimated quantities of ground water in storage in the Kansas portion of the study area are shown below:

County	Acre-feet of Ground Water in Storage 1/
Greeley	2,755,000
Wichita	5,040,000
Scott	3,441,000
Lane	1,491,000
Ness	643,000
Rush	215,000
Barton	4,744,000
Hamilton	2,135,000
Kearny	13,567,000
Finney	26,130,000
Hodgeman	940,000
Pawnee	4,568,000
Edwards	8,270,000
Ford	8,871,000

TABLE 12

PROJECTED INDUSTRIAL WATER DEMANDS

COUNTY	1970 MGD	1970 ACRE-FEET	1980 MGD	1980 ACRE-FEET	2000 MGD	2000 ACRE-FEET	2020 MGD	2020 ACRE-FEET	2070 MGD	2070 ACRE-FEET
COLORADO										
Cheyenne	0	0	0	0	0	0	0	0	0	0
Elbert	0	0	0	0	0	0	0	0	0	0
Kiowa	0	0	0	0	0	0	0	0	0	0
Lincoln	0	0	0	0	0	0	0	0	0	0
Prowers 1/	0.38	430	0.47	521	0.74	830	1.07	1,200	1.70	1,900
1/ Preliminary										
KANSAS										
Barton	0.78	876	1.66	1,191	2.20	2,459	2.80	3,140	10.72	12,003
Edwards	0.07	81	0.12	129	0.23	261	0.37	414	1.34	1,500
Finney	1.01	1,134	1.21	1,350	1.75	1,961	2.68	3,006	10.19	11,414
Ford	0.81	911	0.97	1,086	1.91	2,137	2.80	3,138	12.51	14,011
Gray	0.01	12	0.02	26	0.07	75	0.12	130	0.67	750
Greeley	0	0	0	0	0	0	0	0	0	0
Hamilton	0	0	0	0	0	0	0	0	0	0
Haskell	0.35	393	0.59	666	1.41	1,578	2.64	2,961	6.47	7,246
Hodgeman	0	0	0	0	0	0	0	0	0	0
Kearny	0	0	0	0	0	0	0	0	0	0

TABLE 12 (Cont'd)

PROJECTED INDUSTRIAL WATER DEMANDS

COUNTY	1970 MGD	1970 ACRE-FEET	1980 MGD	1980 ACRE-FEET	2000 MGD	2000 ACRE-FEET	2020 MGD	2020 ACRE-FEET	2070 MGD	2070 ACRE-FEET
KANSAS (Cont'd)										
Lane	0.02	17	0.02	28	0.05	54	0.07	78	0.26	294
Ness	0.01	4	0.01	5	0.01	7	0.01	8	0.03	29
Pawnee	0.03	39	0.03	38	0.04	46	0.06	62	0.20	226
Rush	0.03	38	0.06	68	0.16	174	0.23	259	0.61	683
Scott	0.38	428	0.52	578	0.93	1,038	1.38	1,542	4.14	4,641
Wichita	0.01	2	0.01	2	0.01	3		5	0.02	24

County	Acre-feet of Ground Water in Storage 1/
Gray	15,016,000
Haskell	25,685,000
	123,511,000

1/ Source: Kansas State Department of Health.

Of the estimated 123,000,000 acre-feet of ground water in storage, much less than this would be available for use due to retnetion and physical and economic factors associated with increasing pumping lift and reduced yields due to drawdown and mining of the ground water reservoir. It is estimated that less than 50% or approximately 60,000,000 acre-feet of the water in the underground reservoir could be economically produced for water supply uses. Recharge rates to the ground water reservoir have been estimated from one-quarter inch to one-half inch per year. Assuming the latter recharge rate, this would contribute about 300,000 acre-feet per year to the ground water reservoir. The Arkansas River and tributaries presently supply about 200,000 acre-feet of water per year for irrigation use in the Kansas portion of the study area.

Present and projected demands for water supplies for irrigation in the Kansas study area by the Kansas Water Resources Board are shown below:

Year	Irrigation Water Demands Acre-Feet per Year
1965	Greater than 1,000,000
1980	Greater than 2,500,000
2000	Greater than 4,000,000
2020	Greater than 4,500,000

A comparison of the above irrigation demands in the Kansas study area with available water resources assuming an initial ground water supply of 60,000,000 acre-feet, a recharge rate of 300,000 acre-feet per year, and a surface supply of 200,000 acre-feet per year is shown on Figure 1. Figure 1 shows that if the projected irrigation demands in Kansas were satisfied using available water resources the ground water reservoir will be depleted by about 2000. In reality this will not happen as economics at some time in the future will make it infeasible to continue further production of the ground water reservoir. It will become economically infeasible to produce ground water for irrigation before it will for municipal and industrial water uses. After this point in time the ground water levels will tend to stabilize. It is expected that much the same situation exists in Colorado as in Kansas due to heavy pumpage of ground water for irrigation.

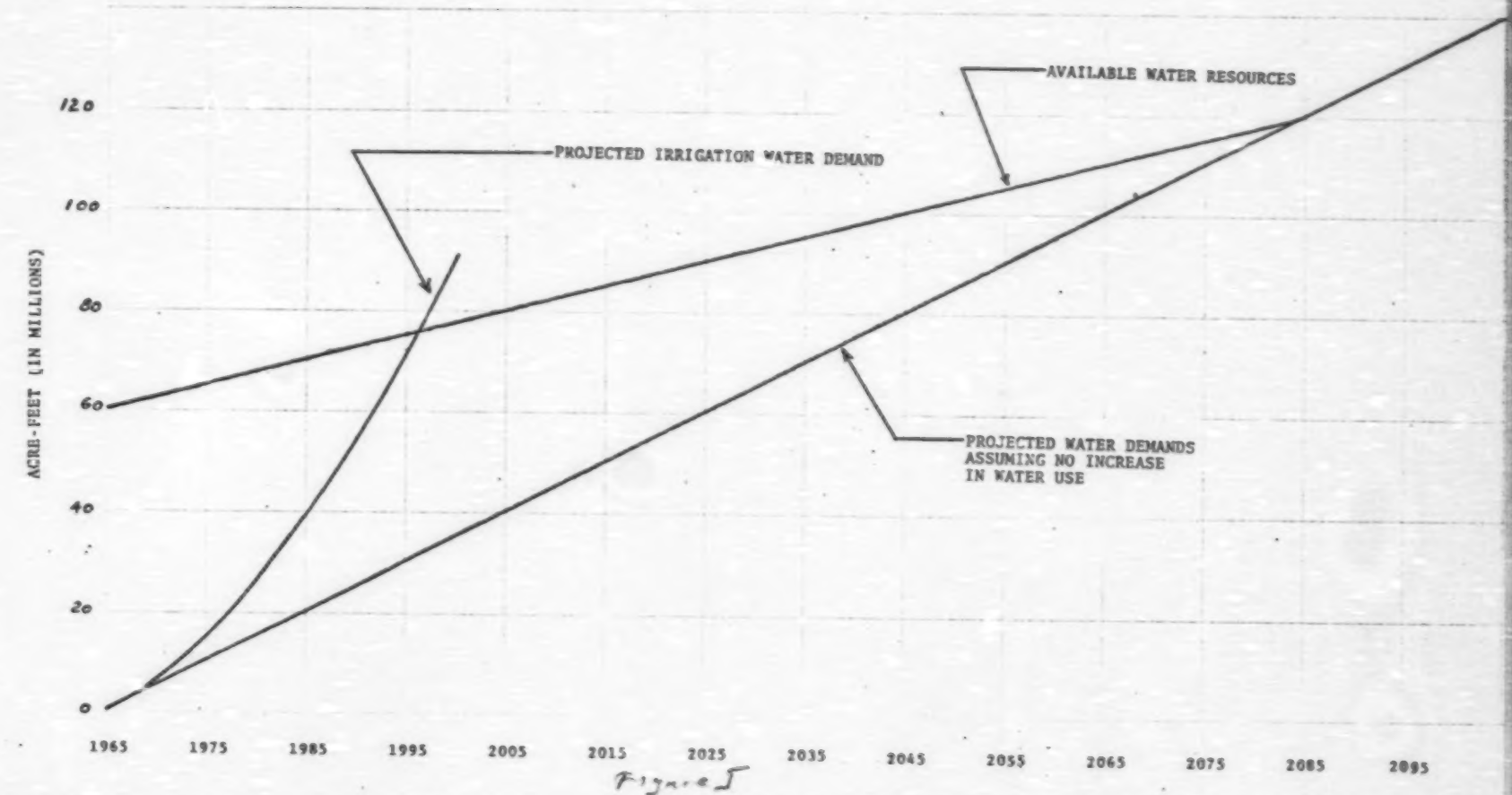
AVAILABLE WATER RESOURCES
PROJECTED IRRIGATION WATER DEMAND
PROJECTED WATER DEMANDS
ASSUMING NO INCREASE
IN WATER USE
ACRE-FEET (IN MILLIONS)
120
100
80
60
40
20
0
1965
1975
1985
1995
2005
2015
2025
2035
2045
2055
2065
2075
2085
2095

Figure 5

It is estimated that 1,000,000 acre-feet of water were pumped for irrigation in Kansas and about 200,000 acre-feet in Colorado during the year 1970 and it is expected that the rate of pumpage will increase. Figure 1 also shows a comparison of the present use rate of 1,000,000 acre-feet in the Kansas study area with available water resources. Assuming no increase in the present water use in the Kansas study area the ground water resources will be depleted by about 2085. Present pumping levels have already caused serious draw down and mining of the underground reservoir in local areas throughout the study area. If production of ground water continues to increase at the present rate the draw down and mining of ground water will become serious throughout the study area. It is also possible that heavy pumpage will result in a deterioration of ground water quality. There is speculation that this is presently occuring in the shallow alluvial aquifers where irrigation has been practiced for many years. However, availiable data are inadequate to determine any conclusive results as to the effects of the heavy pumpage on ground water quality.

D. Water Quality Problems

There are 6 municipal water supplies in the study area in Colorado and 15 in Kansas where the mineral content

exceeds maximum limits recommended in the U.S. Public Health Service Drinking Water Standards. The chemical constituents violating recommended standard are flourides (F), sulfates (SO_4), chlorides (cl), and total dissolved solids (TDS). The upper limits recommended for the above constituents are shown below:

Chemical Constituent	Recommended Limit Concentration-ppm
TDS	500
Chlorides	250
Sulfates	250
Flourides	1.7 1/

1/ Based on average annual temperature of 50-53°F

The communities that have public water supplies with mineral concentrations exceeding recommended limits are shown below:

Community	Constituent Exceeding Standards ppm
Colorado	
Eads	TDS-1,150; SO_4-553
Hugo	TDS-667
Kit Carson	TDS-1,220; SO_4-605
Limon	TDS-1,090; SO_4-556
Simila	TDS-604
Wiley	TDS-2,090; SO_4-1,060; F-2.2
Kansas	
Alexander	TDS-556
Burdett	F-2.0
Bazine	TDS-849

Bison	TDS-556
Dighton	F-3.2
Ellenwood	TDS-920; SO_4-400
Great Bend	TDS-729
Jetmore	TDS-600
Larned	TDS-1,120; SO_4-565
Libenthal	TDS-1,741; Cl-670; F-4.4
McCraken	TDS-534
Ness City	TDS-614
Olmitz	TDS-1,246; Cl-471; F-2.0
Scott City	F-2.0
Susank	TDS-2,187; Cl-945; F-2.8

1/ Public Water Supplies of Colorado, 1959-1960, prepared by U.S. Geological Survey in Cooperation with Colorado State University Agricultural Experiment.

2/ Chemical Quality of Public Water Supplies in Kansas November 1968, Kansas State Department of Health.

The above analysis are somewhat misleading in that some of the communities have more than one well and may produce water from several aquifers having varying quality. Insome cases the above analyses are for only one well and may not be representative of the community water supply. Also, U.S.P.H.S. Drinking Water Standards are recommended limits and exceedance of these limits does not necessarily make a water supply unuseable or dertimental to drink.

Chemical analyses of municipal water supplies for the period 1958 through 1971 furnished by the Kansas State Department of Health show that only 6 of the water supplies in the Kansas study area presently have a chemical quality that warrants consideration of developing another source of water supply solely for improvments in quality. These communities are Dighton, Ellinwood, Larned, Libenthal, Olmitz, and Susank. A seventh community, Jetmore, has analyzed chemical quality of 4 wells nearby in an effort to supplement its existing water supply. However, water from the wells was high in flouride content (averaging about 3.0 ppm) and it was recommended by the Kansas State Health Department that they not be used. Also, 2 of the shallow wells used for production of water

supply for Jetmore have experienced significant drawdown and their yields have been significantly reduced. The projected demands for these seven communities are shown in Table 13.

It would be beneficial for these seven communities to develope a source of water supply of better quality. The alternative of supplying this water must be either from groundwater sources other than those presently used or surface water sources. Water quality records of wells in the study areas furnished by the U.S.G.S. show that in some areas the groundwater meets U.S.P.H.S. standards recommended for drinking water. These records also show that portions of the study area are underlain by groundwater that would not be of desirable quality for municipal use. In local areas, heavy pumpage for irrigation has caused significant drawdown and reduced the yields of wells. In view of these problems, specific areas suitable for the development of groundwater for municipal use cannot be defined without extensive production tests of wells to determine the yields and the effects of pumpage on water quality and drawdown. In lieu of developing groundwater sources for water supply, the Horse Thief Canyon Reservoir would provide an acceptable source of municipal water supply. However, due to the location and capacity of this reservoir it is incapable of supplying the water needs of the seven communities shown in Table 13.

TABLE 13

PROJECTED WATER SUPPLY DEMANDS

COMMUNITY	1970		1980		2000		2020		2070	
	MGD	Acre-Feet	MGD	Acre-Feet	MGD	Acre-Feet	MGD	Acre-Feet	MGD	Acre-Feet
Dighton	0.31	347	0.44	493	0.57	639	0.79	885	1.54	1,725
Ellinwood	0.41	479	0.41	470	0.42	470	0.42	470	0.33	370
Jetmore	0.22	248	0.24	269	0.28	314	0.28	314	0.32	358
Larned	0.95	1,065	0.99	1,109	1.46	1,635	1.61	1,804	1.92	2,151
Libenthal	0.02	24	0.03	34	0.03	38	0.04	42	0.04	42
Olmitz	.03	39	0.03	40	0.04	49	0.05	59	0.07	83
Susank	.01	10	0.01	11	0.01	13	0.01	14	0.01	16

V. Findings and Conclusions

A. Findings

1. Reservoir storage for water quality control releases is not justified.
2. High concentration of sulfates and total dissolved solids make the Arkansas River water unsuitable for municipal use and most industrial uses.
3. A limited number of samples show that the water impounded by the Horse Thief Canyon reservoir would be suitable for municipal and industrial uses. Additional water quality analyses of this project would be required prior to developement of this site for a water supply.
4. Due to heavy pumpage of ground water for irrigation in the study area, local areas are experiencing a lowering of the ground water level and mining is occuring. This condition will become widespread throughout the study area if the pumpage of groundwater continues to increase at present rates.
5. If the projected demands for irrigation in the Kansas study area were to be satisfied with existing water resources, by about the year 2000 the groundwater will be depleted. A similar situation is expected to exist in the Colorado portion of the study area.

6. If appropriation of groundwater for irrigation is regulated, municipal and industrial water demands can be satisfied with groundwater resources.

7. If pumpage of groundwater for irrigation increases at prevailing rates, drawdown will adversly affect the yields of municipal and industrial water wells in the study area.

8. Increased pumpage could possibly result in a deterioration of groundwater quality making it unsuitable for municipal and industrial uses.

9. There are seven known communities in the study area in Kansas which should seek water supplies having better quality.

10. The capacity of the Horse Thief Canyon Reservoir project being investigated is inadequate to supply the needs of these seven communities.

11. There are so many complicating factors associated with the mining of the groundwater that it is impossible to predict the future quality and quantity of groundwater in the study area with any degree of accuracy without detailed field study.

B. Conclusions

1. The appropriate Federal and State agencies should make a detailed study to determine the affect of present and projected groundwater pumpage on future groundwater quality and quantity.

2. This study should be directed toward determining the "safe yield" of the groundwater reservoir and could serve as a tool for the states in permitting future groundwater use. Such a study should also define the specific location of areas where groundwater resources are suitable for development as a source of municipal and industrial water supplies.

3. Until a study of this scope has been made and the states establish a program for the management of groundwater resources, it is impossible to accurately depict the future supplemental municipal and industrial water supply needs in the study area.

4. There are seven known communities in the Kansas study area that have an existing need to develop new sources of water supply of a better quality.

The Horse Thief Canyon Reservoir project could satisfy a portion of these needs and there would be a benefit attributable to development of this project for municipal water supply. However, available data is insufficient to determine if groundwater or surface water development would be the least costly alternative in satisfying these needs and additional studies of the future groundwater resources should be made.